

The Galactic Harbour and the Transportation Story



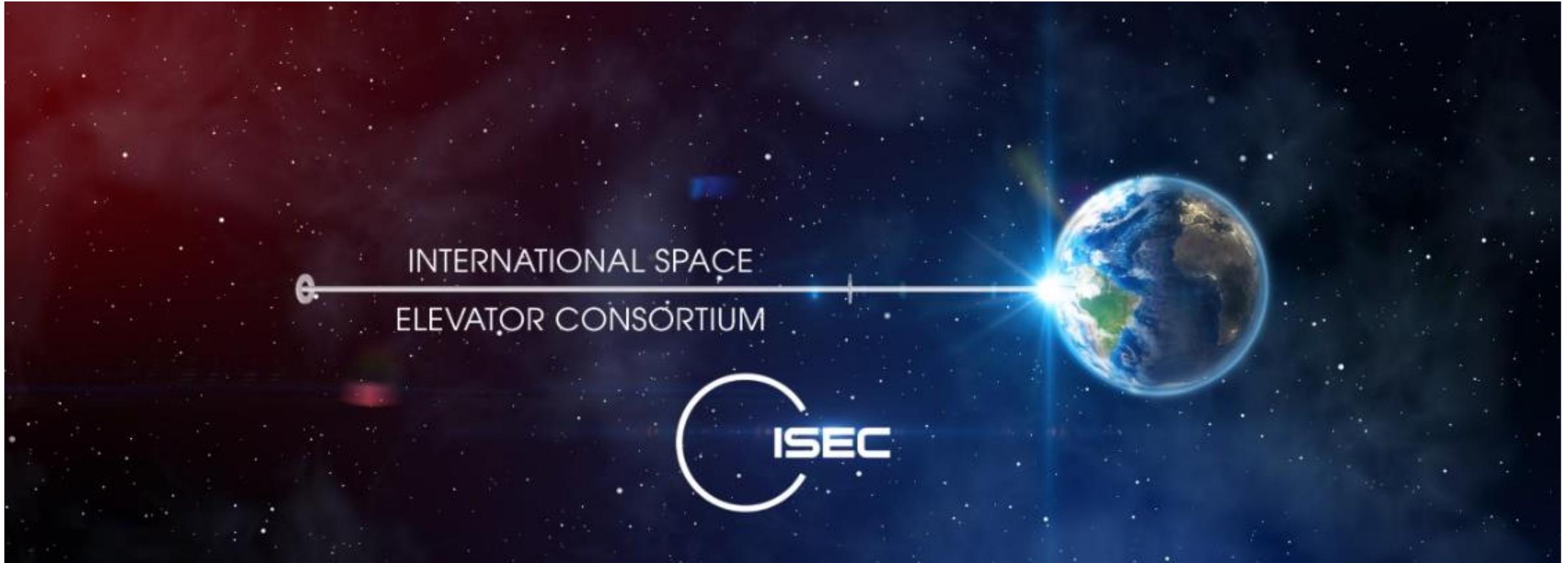
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Michael Fitzgerald, Chief Architect and Board Member, ISEC
EVP & Co-Founder - Galactic Harbour Associates, Inc.

NASA Ames Webinar 23 September 2020

16:00 Coordinated Universal Time (UTC)

9:00 Pacific Time





Michael Fitzgerald – “Fitzer”



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ISEC Board member
Chief Architect



**The International Space
Elevator Consortium**

USAF Academy 1968

University of Southern California 1978

Over 50 years experience in major projects:

- ❖ Space based surveillance & communications
- ❖ ICBMs; including the mobile ICBM
- ❖ Funny looking airplanes
- ❖ Hypersonic flight systems





What we will cover...



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- Galactic Harbour
- Space Elevator segments and adjuncts
- Architecture Engineering
- Technology Maturity
- Transportation Elixir
- Interplanetary Transportation Network

The Galactic Harbour

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Los Angeles and Long Beach Harbor



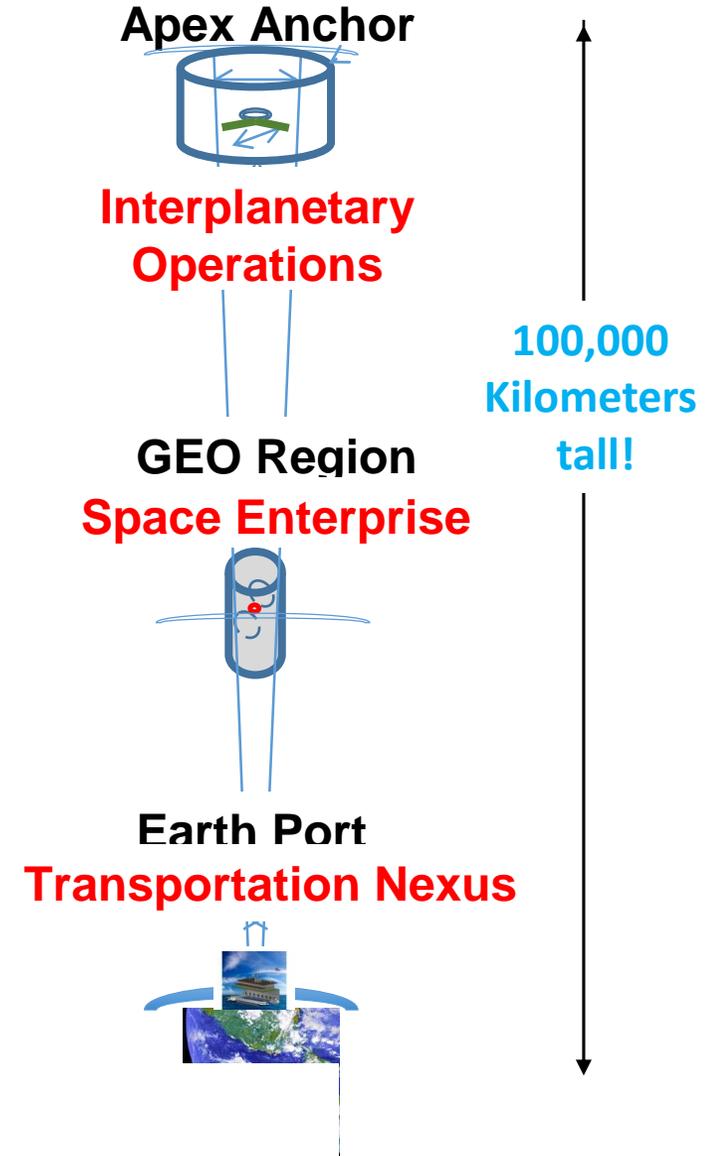
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Galactic Harbour

Galactic Harbour Architecture A Mega Project

This is the transportation story of the 21st century.
Reliable, safe, & efficient access to space.



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Galactic Harbour Basics

1. Space Elevator Transportation System is the 'main channel' in the Galactic Harbour.

- **Apex Region**
- **GEO Region**
- **Earth Port**
- **HQ/POC**
- **14 Climbers**
- **2 Tethers**

2. Businesses flourish within the Harbour - as the Space Elevator Enterprise System

- **Business support to Operational Satellites**
- **Interplanetary Efforts within reach**
- **Power and Products delivered to Earth**
- **Research**

Galactic Harbour - The Unifying Vision It is the combination of the Space Elevator Transportation System & the Space Elevator Enterprise System

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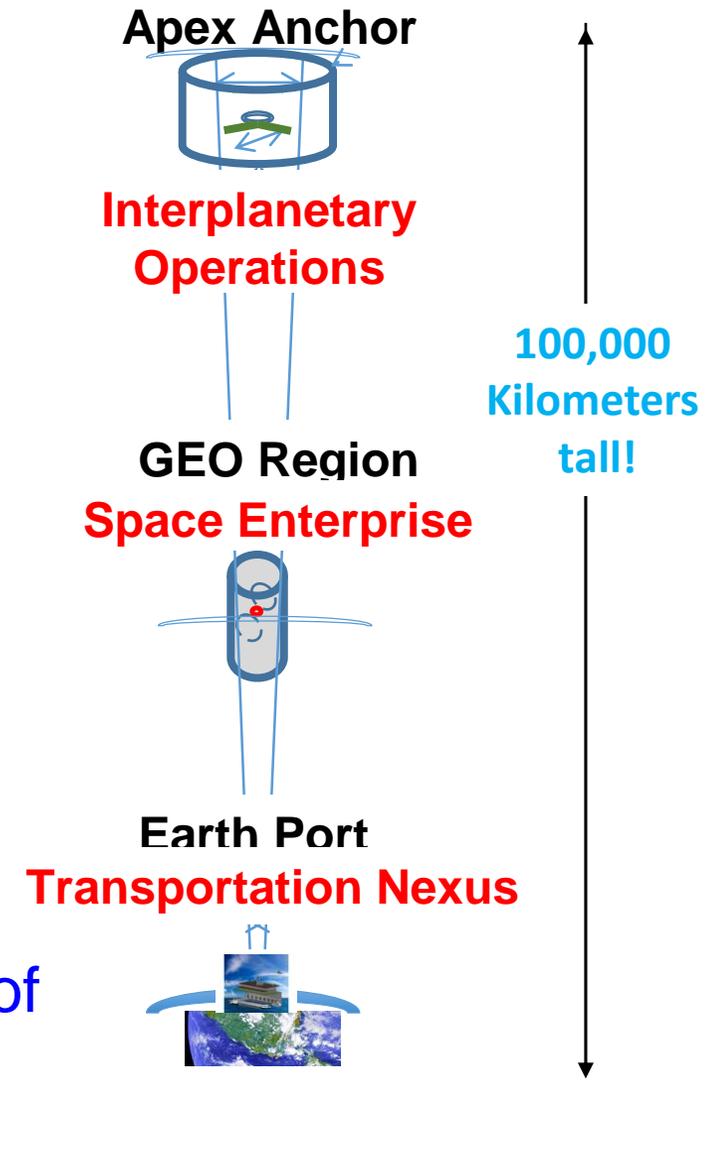
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Galactic Harbour Architecture

This is the transportation story of the 21st century. Reliable, safe, & efficient access to space; close at hand.

Galactic Harbour - The Unifying Vision - is the combination of the Space Elevator Transportation System & the Space Elevator Enterprise System



The Architecture's Adjuncts

The Operating Architecture that we see ... by mid Century

“Adjunct Components”

A Concept Summary

“Space Debris Adjunct Component”

Current Policy portrays Debris Mitigation will be fully “underway”
by the middle of the next decade
Circa 2025

The Space Elevator Transportation system
will establish a close and interactive operational relationship.

- **The Sentry System** -

Space Elevator Operations Space Debris

Architecture Note #25 Space Elevator Architecture's Debris Mitigation Roles

Debris alert

Debris sizing

Space Elevator Tether Movement

The Sentry System

System Recovery

→ *Warning needs*

→ *As a threat variant*

→ *Passive defense*

→ *Active Defense - An Architecture adjunct*

→ *Post debris-event actions*

“Space and Surface Object Management Adjunct Component”

Objects within and approaching the Space Elevator Regions will be actively “tagged”, monitored, and controlled

The Space Elevator Transportation system will establish a close and interactive operational relationship.

With the

- **Combined Space Operations Command Center** -

Space Elevator Operations

Space and Surface Object management

Architecture Note #XX Space Elevator Architecture's Situational Self Awareness

Operations Inventory – Object count
Interface with CSpOC
Space Object dynamic element sets
Interface with ????
Client product / cargo tracking
Data processing / data analysis

➔ *Positive Control*
➔ *Space Situational Awareness*
➔ *Collision avoidance*
➔ *“Earth Surface” Situational Awareness*
➔ *Active control - An Architecture adjunct*
➔ *Record of activity*

“Client Support and Management Adjunct Component”

**Under
Construction**

The Space Elevator Transportation system will establish a close and interactive relationship, with its supply chain and transportation clients /customers

- **Access City HQ/POC Client “chair”**

**Under
Construction**

Space Elevator Transportation Infrastructure
-- Architecture Engineering 101 --

Space Elevator Operations Client Support

Architecture Note #XX
**Space Elevator Architecture's
Client Support Services**

Client Compatibility

Client Readiness

Space Elevator Access city

Space Elevator Supply Chain

Space Elevator Good Neighbor

➔ *Ops and Safety*

➔ *Climber schedule management*

➔ *Depot-like support and maintenance*

➔ *Recurring and Responsive support management*

➔ *Local impact*

Architecture Engineering ?

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Understand Architecture Engineering?

→ compare it with System Engineering



System Engineering

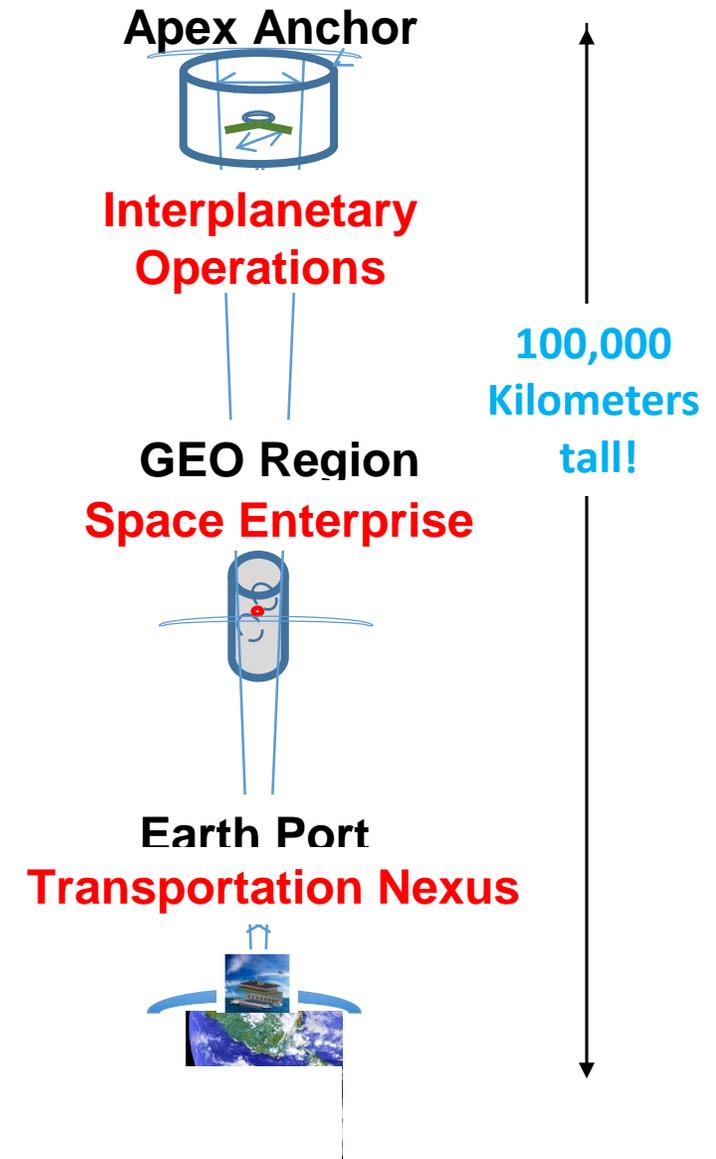
1. Assemble the compatible
2. Sub-optimization is inevitable
3. DII / COE
4. Clean Interfaces
5. Modeling and simulation
portrays how will operate ...
anomalies are solved
6. System Performance
7. Block Upgrades
8. System to Segments to ...
9. BITE

Architecture Engineering

- 1. Assemble the incompatible
2. Optimization is an imperative
3. OPEN
- 4. Intelligent Interfaces
- 5. Modeling and simulation projects
operational alternatives ...
anomalies are avoided
6. Job Success
- 7. Adaptive Evolution
8. Domains and sub domains and
...
9. Agents and Synoptic Monitoring



The Earth Port



The Earth Port's Floating Operations Platform (As Presently Envisioned)

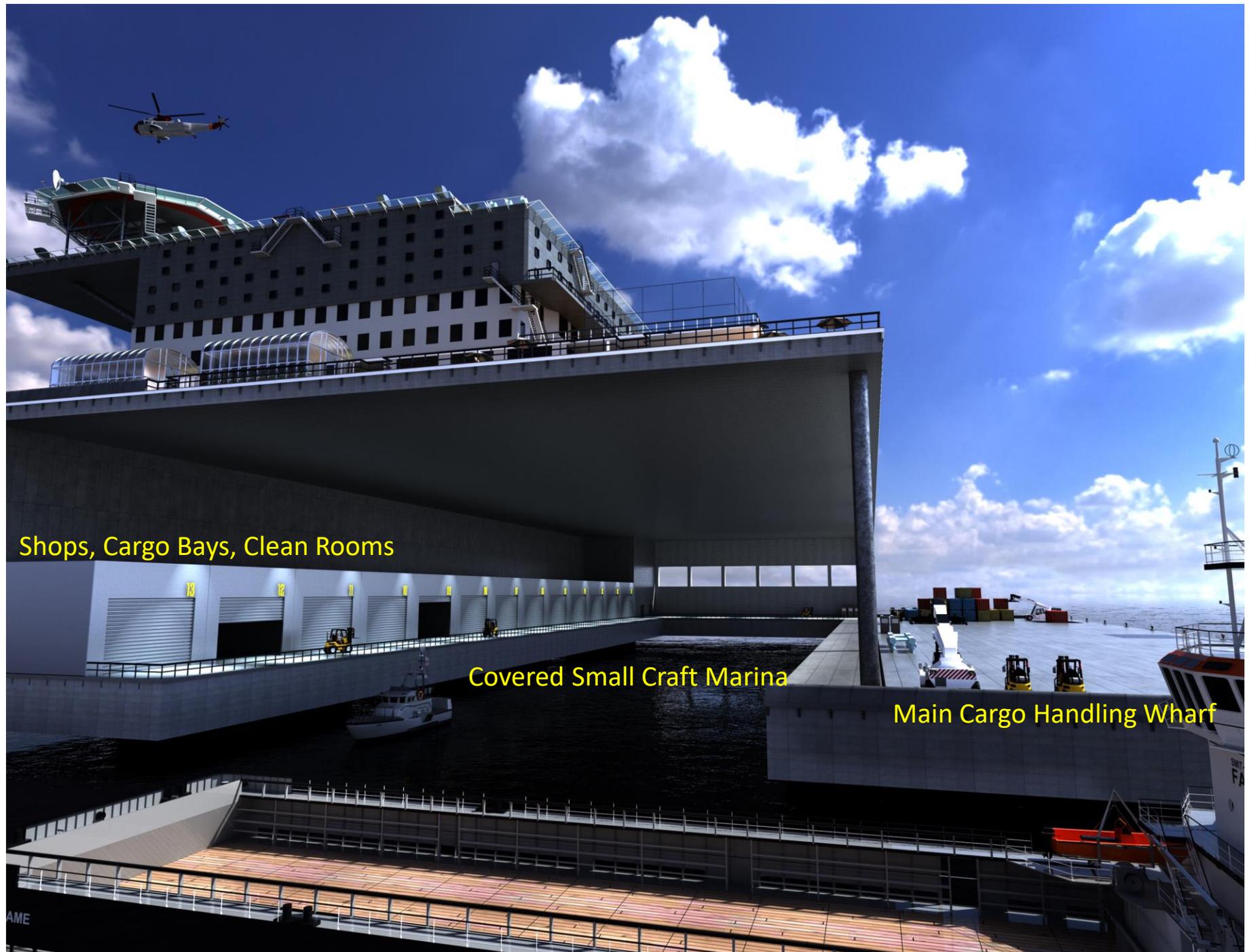


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Image by Lux Virtual

The Floating Operations Platform Key Features



Shops, Cargo Bays, Clean Rooms

Covered Small Craft Marina

Main Cargo Handling Wharf



Primary Operations Center



Elevator Operations
Center

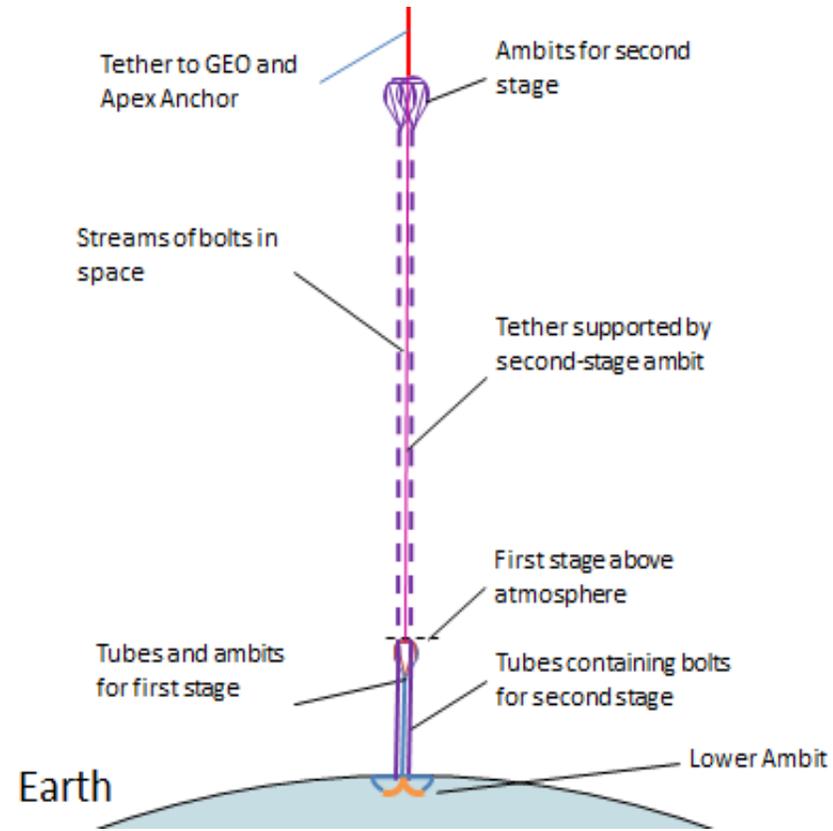
Everything under
positive control

The Earth Port Platforms

Tether Terminus



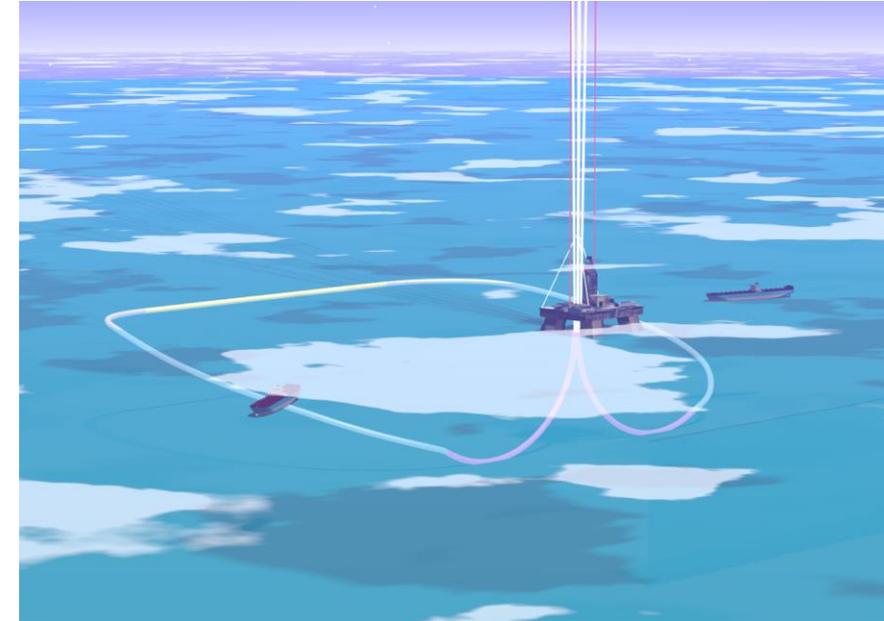
The Multi-stage Space Elevator: an alternative to the single ribbon design



International Space Elevator Consortium ISEC Position Paper # 2019-1

Design Considerations for the Multi-stage Space Elevator

John M. Knapman
Peter Glaskowsky
Dan Gleeson
Vern Hall
Dennis Wright
Michael Fitzgerald
Peter A. Swan





The Tether

Graphene: The new material revolution

200 times stronger than steel



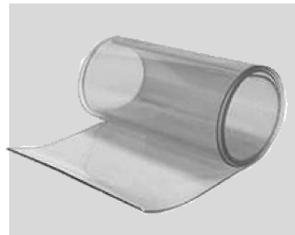
World's best conductor of electricity



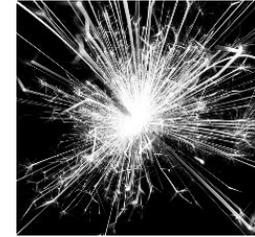
Very stable material



Flexible and transparent



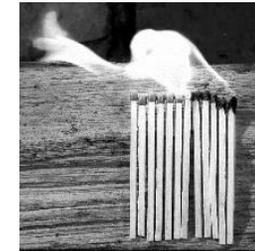
Highest melting point of any material in a vacuum



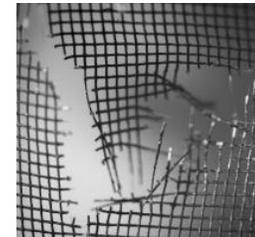
100 times more tear resistant than steel



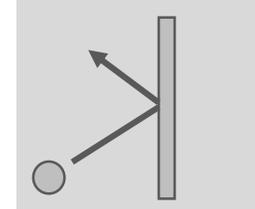
World's best conductor of heat



World's most fatigue resistant material



World's most impermeable material



Combine the tether layers in orbit...



● ● ● ● Single crystal graphene
roll cassettes

● ● Pinch rolls forming
Multilayer graphene
(Graphitic) tether
'Nixene'



Feasibility of building the tether...

How big is a reel of single crystal graphene
100,000km long?

20mm core
1000mm wide

300mm Diameter

How much would it weigh?

77kg

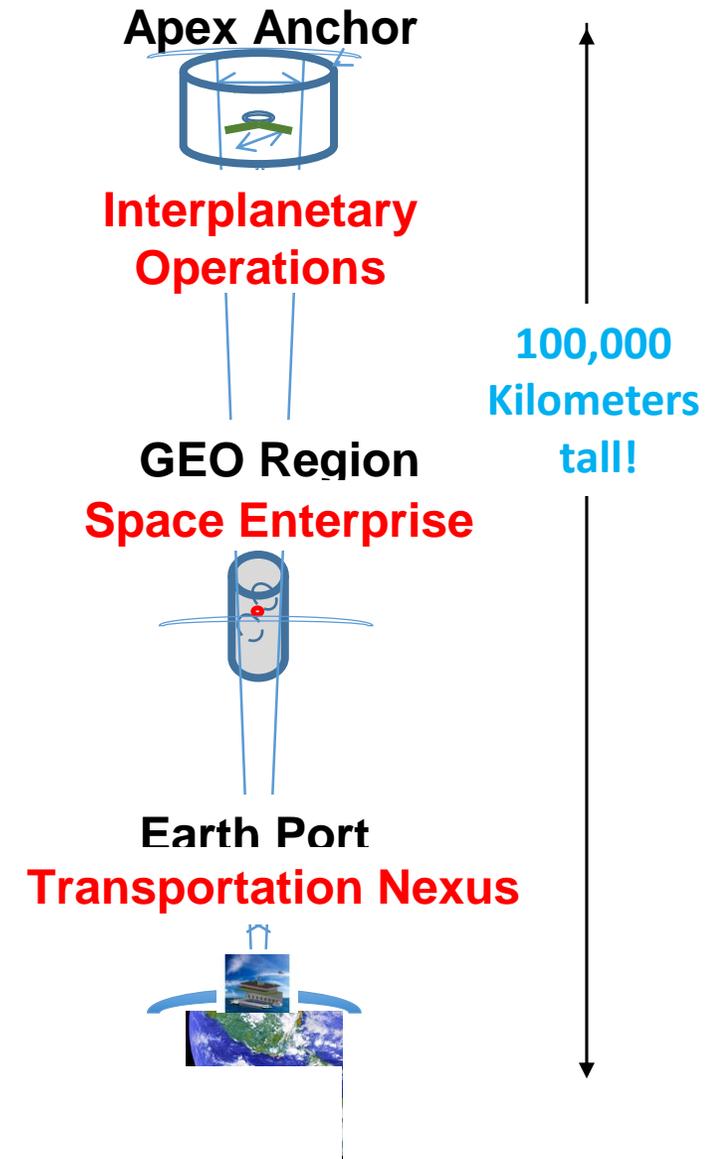
Dr. Peter Clark helped with the calculations...



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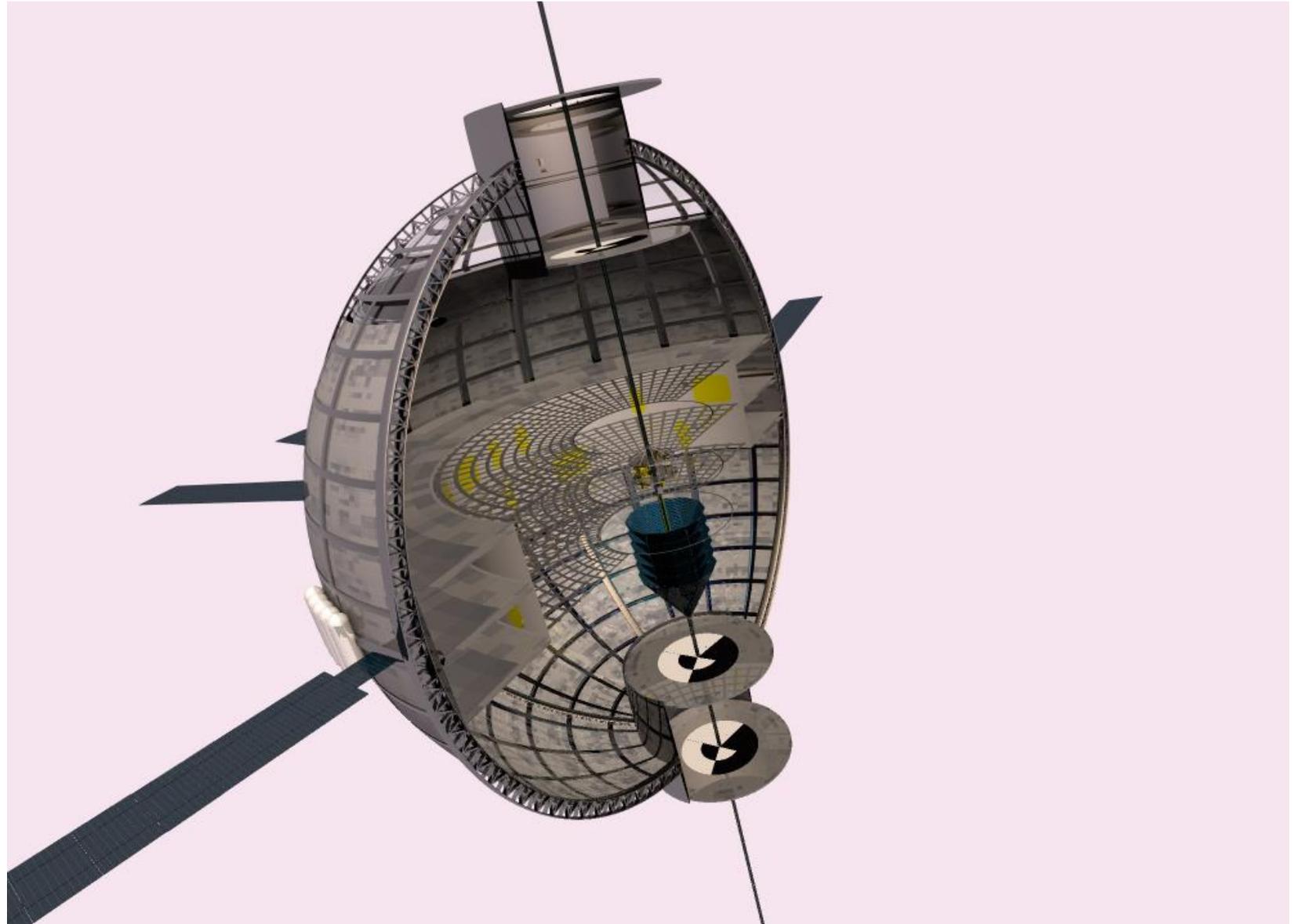
The GEO Region



The Old View -
7+ years ago

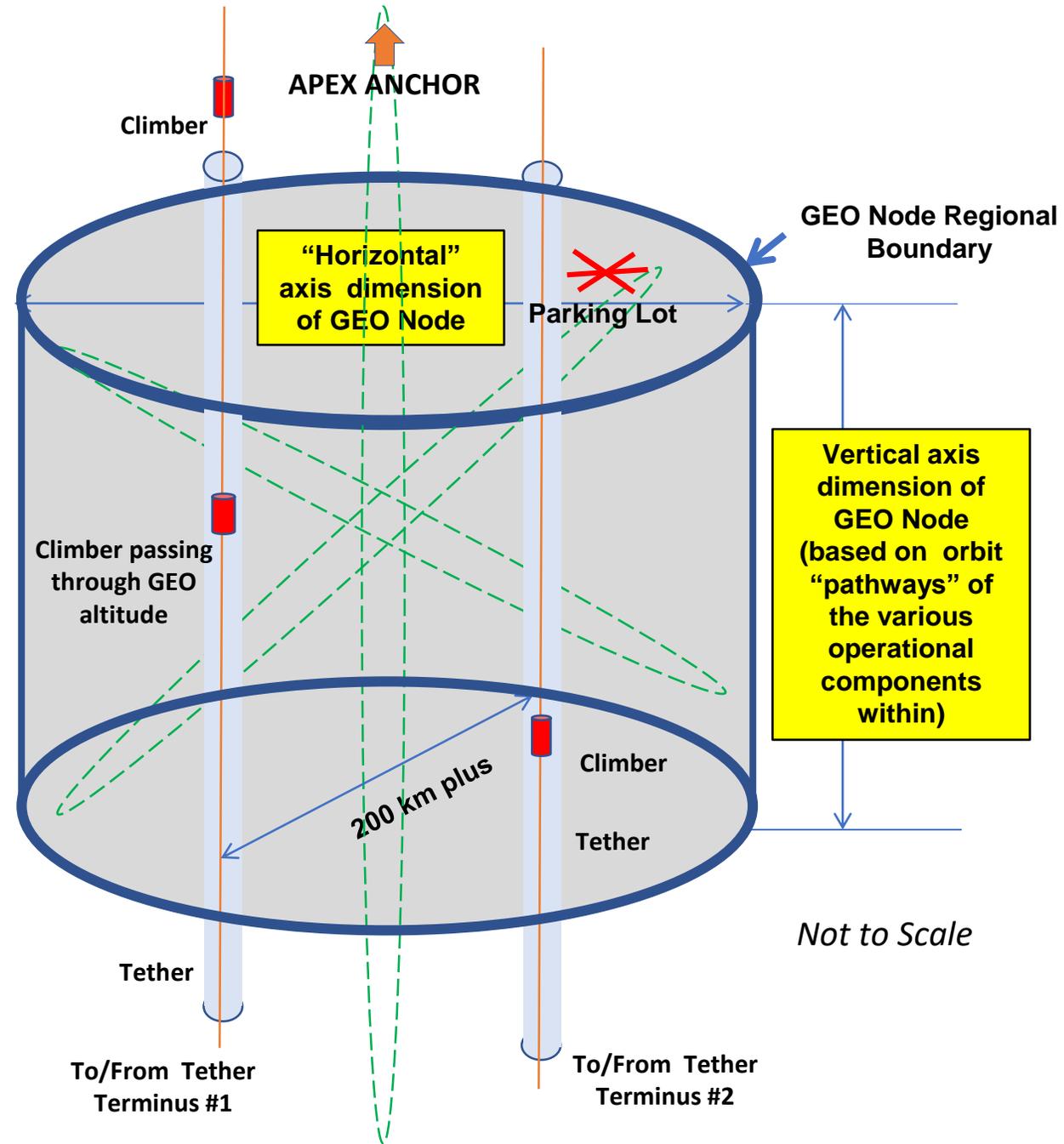
**SPACE ELEVATOR
GEO NODE**

As envisioned in the
2013 IAA report

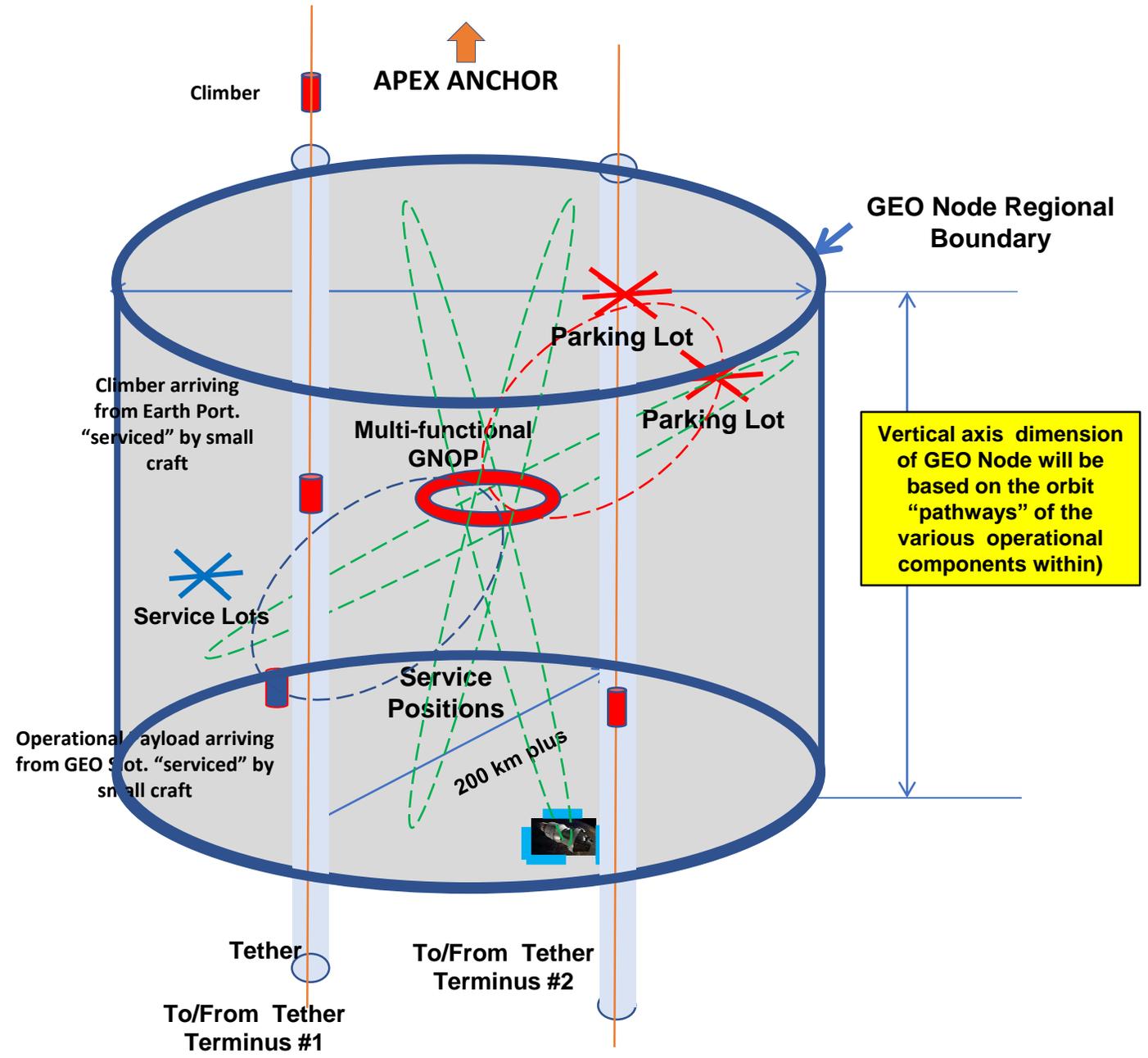


The New View

SPACE ELEVATOR GEO Region AT IOC



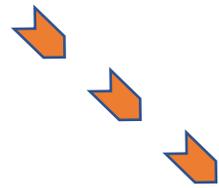
SPACE ELEVATOR GEO Region AFTER IOC



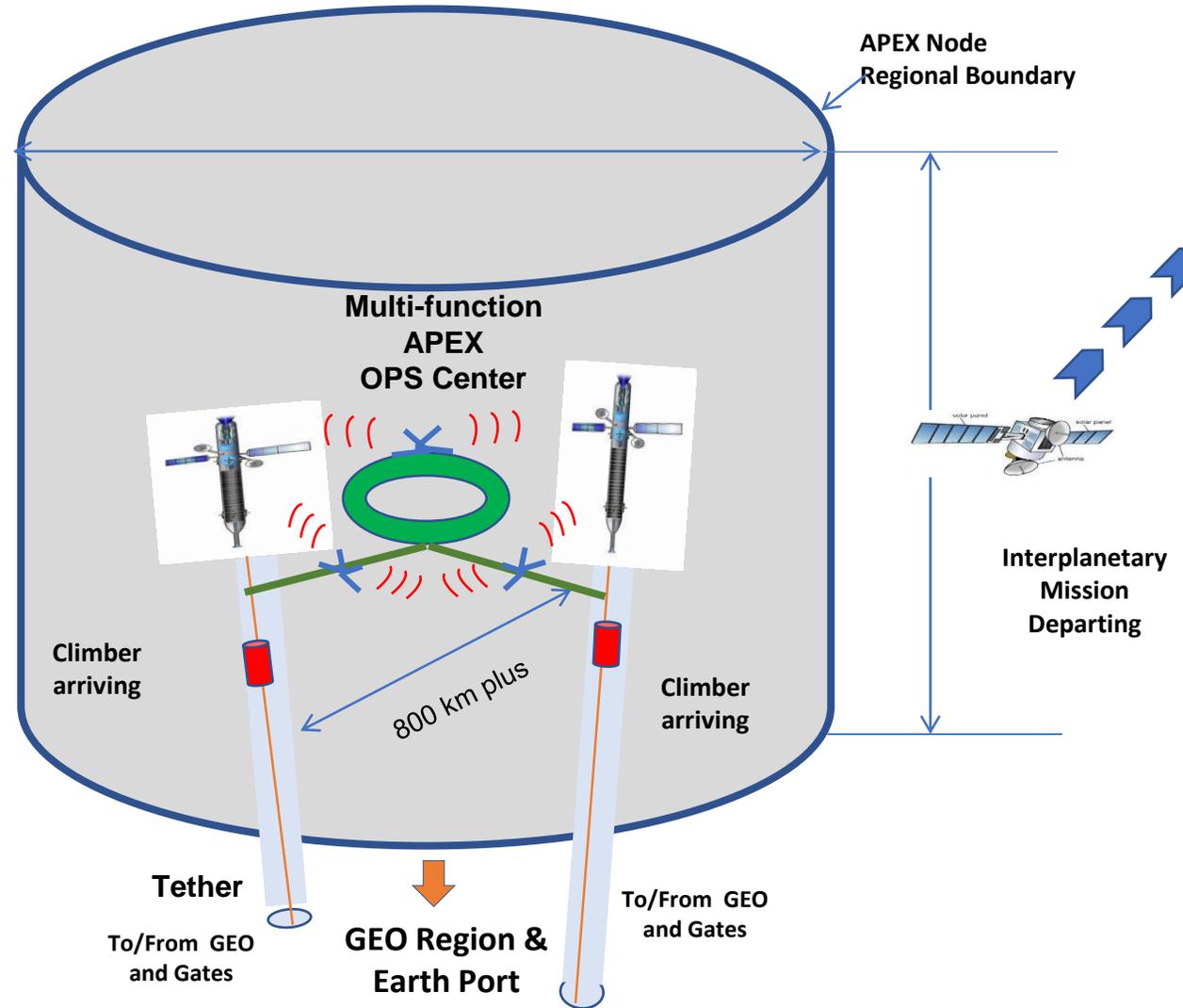


The Apex Region

SPACE ELEVATOR APEX Region AFTER IOC



Interplanetary
Mission
Arriving



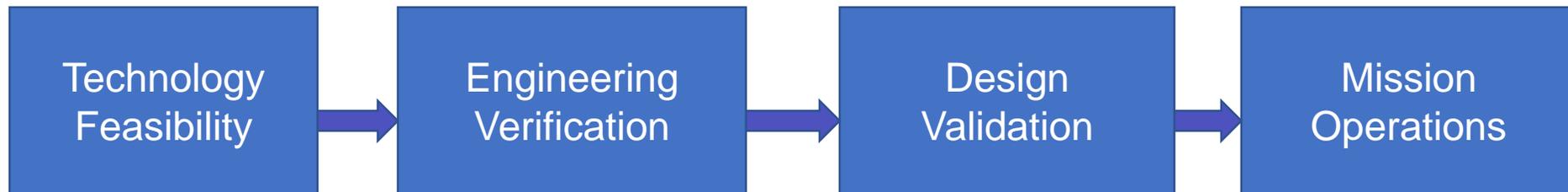


Technology Maturity and Readiness

Galactic Harbour Technology Development Strategy

-- Architecture Engineering 101 --

Stages of “Maturity” Roadmap



What are we doing?

Phase One Technology Feasibility & Readiness (based on a concept baseline)

- 1. Document technology readiness state.**
- 2. Establish readiness level rationale for all portions of the Program.**
- 3. Set Success Criteria regarding Engineering Approach Verification**

ISEC Position Paper # 2014-1; [“Space Elevator Architecture and Roadmaps”](#);

What will we be doing?

Phase Two -- Engineering Approaches.

Phase two is driven by six major activities:

- 1. Determine if it can be built:**
- 2. Examine Industry's technology maturation approaches:**
- 3. Assess schedule & technical risk:**
- 4. Delineate "On Ramp" Criteria:**
- 5. Set criteria and standards regarding Design Validation:**
- 6. Baseline Technical Performance:**

Space Elevator Development Phases “SEQUENCES”

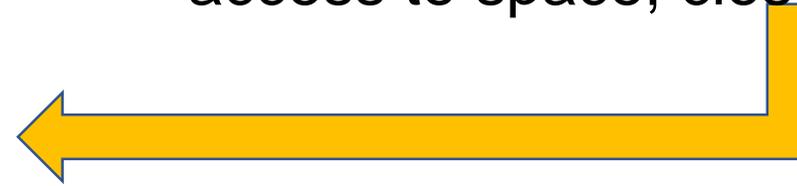
1. Pathfinder
2. Seed Tether,
3. Single String Testing
4. Operational Testing,
5. Limited Operational Capability (LOC),
6. Initial Operational Capability (IOC),
7. Capability On Ramps leading to FOC
8. Full Operational Capability (FOC)



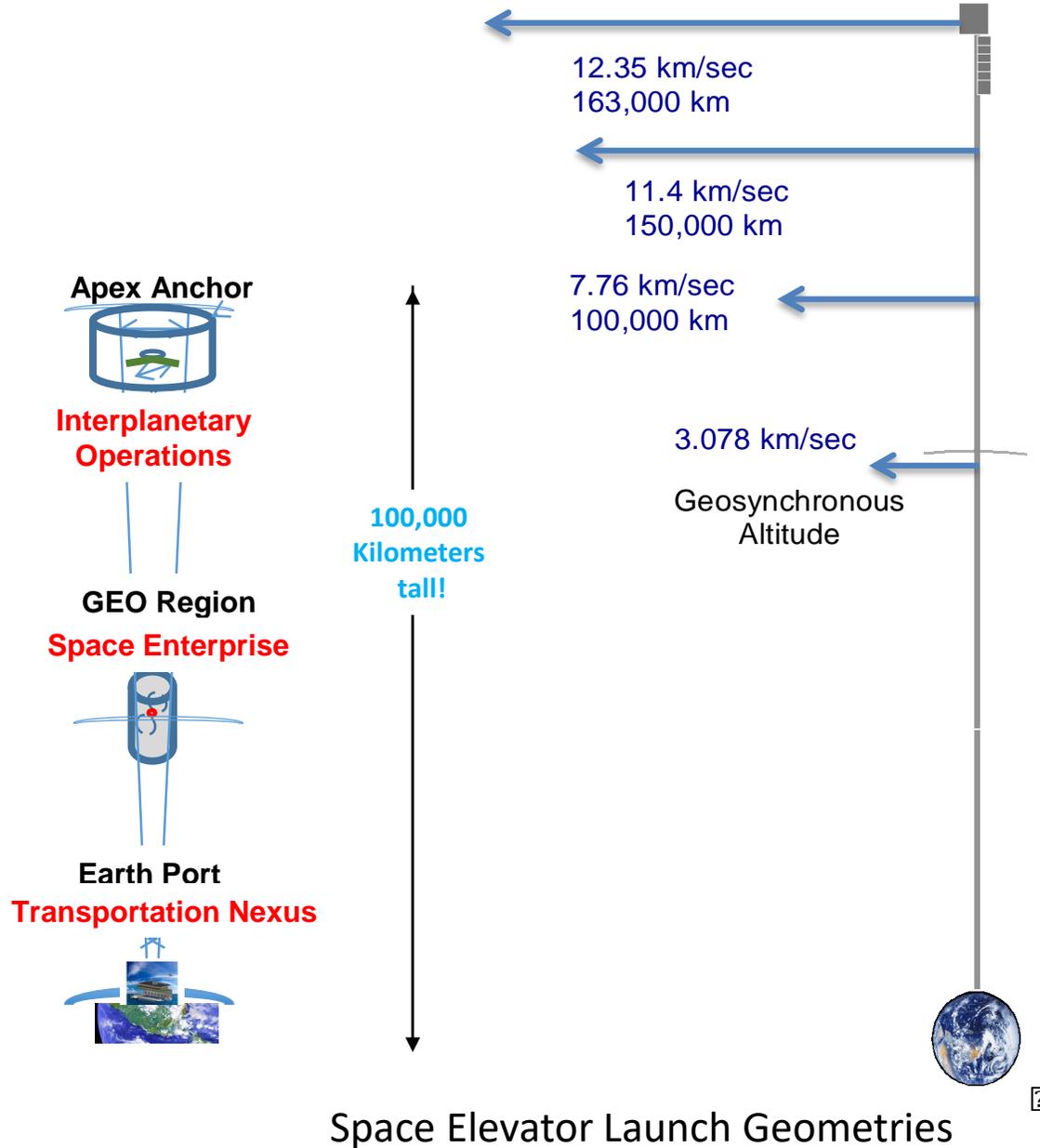
The Transportation Elixir

Apex Region

This is the transportation story of the 21st century. Reliable, safe, & efficient access to space; close at hand.



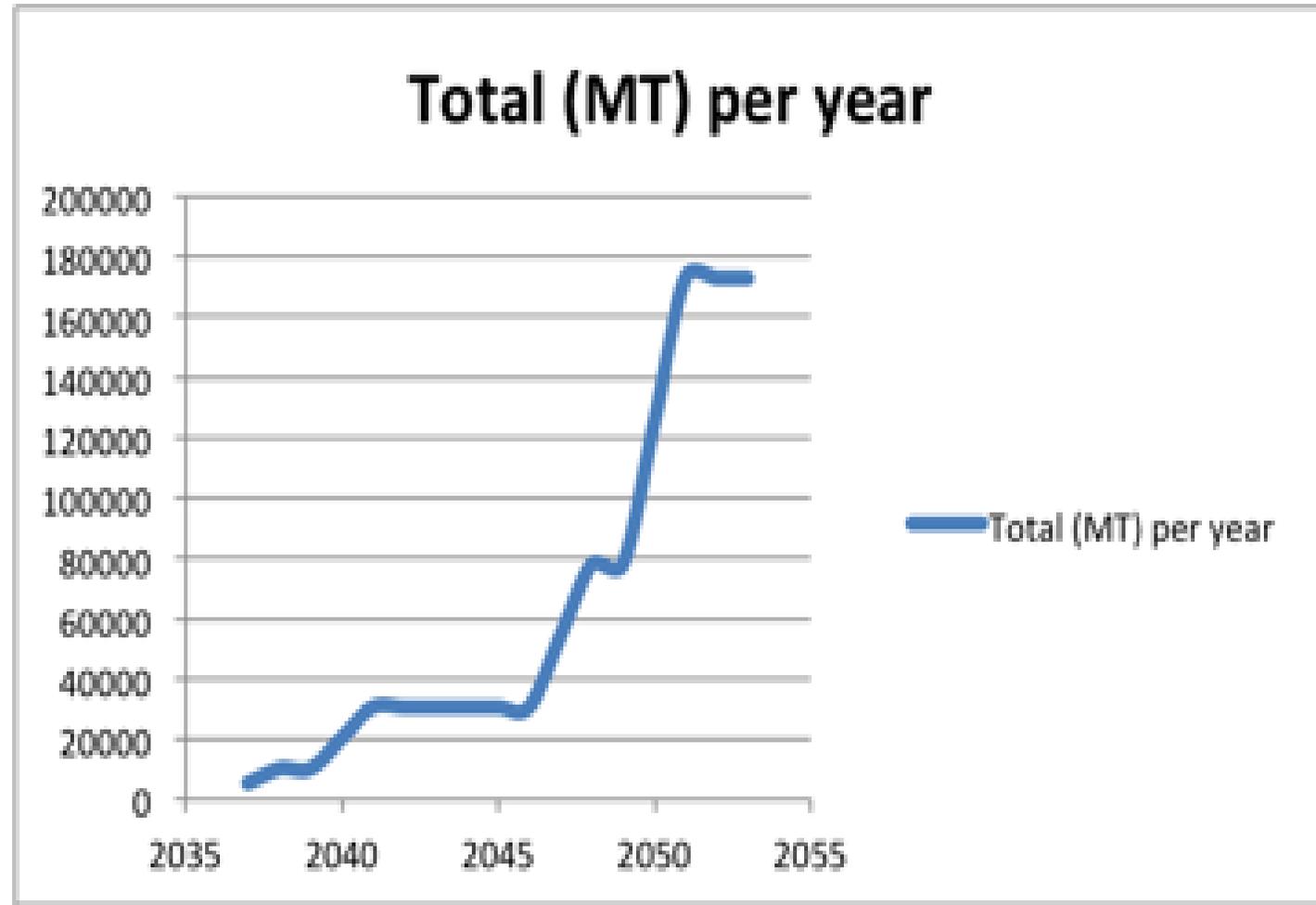
Galactic Harbour – velocity on account



Torla, James and Matthew Peet,

"OPTIMIZATION OF LOW FUEL AND TIME-CRITICAL INTERPLANETARY TRANSFERS USING SPACE ELEVATOR APEX ANCHOR RELEASE: MARS, JUPITER AND SATURN,"

International Astronautics Congress (IAC-18-D4.3.4),
Washington D.C., 2019.



Interplanetary Transportation Throughput

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<i>Demand in Metric Tons</i>	2031	2035	2040	2045
Space Solar Power	40,000	70,000	100,000	130,000
Nuclear Materials Disposal	12,000	18,000	24,000	30,000
Asteroid Mining	1,000	2,000	3,000	5,000
Interplanetary Flights	100	200	300	350
Innovative Missions to GEO	347	365	389	400
Colonization of Solar System	50	200	1,000	5,000
Marketing & Advertising	15	30	50	100
Sun Shades at L-1	5,000	10,000	5,000	3,000
Current GEO satellites + LEOs	347	365	389	400
Total Metric Tons per Year	58,859	101,160	134,128	174,250

Table 13-V. Projected Demand [MT/yr]

Interplanetary Transportation REQUIREMENTS



Interplanetary Transportation Network



Today's Intermodal container-based shipping network serves the Planet Earth



The Third Dimension now

The Third Dimension soon



The Galactic Harbour expands Earth's Transportation Network to the Solar System

Thank you for your time

This is the Transportation story of the 21st Century
We will keep you informed

“Fitzer”

Michael.Fitzgerald@cox.net



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**The International Space
Elevator Consortium**

You can become a member of ISEC starting from just \$25

www.isec.org